PERSPECTIVES ON SPACE FUTURE

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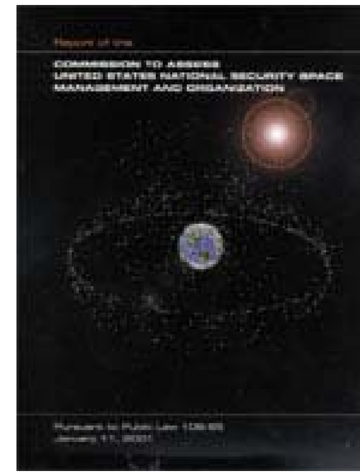
LAUNCH VEHICLES, MICROSATELLITES AND CISLUNAR SPACE

- WHAT'S NEW IN DoD?
- ACCESS TO SPACE
  - U.S. Dilemma – cost too much and takes too long
  - Shuttle Problems, EELV Limitations
  - Short Term – Small Launch Vehicles
  - Long Term, Reusable
    - Hypersonics/Airbreathers vs Rockets
    - Horizontal vs Vertical
- MICROSATELLITES
  - U.S. has largely ignored
  - "Responsive" potential
- CISLUNAR/TRANSLUNAR OPPORTUNITIES
  - NEOS
  - Large Telescopes, Lunar Resources

Organization and Money

- 2002 – Implementation of “Rumsfeld” Commission
- 2002 – Reorganization of Air Force and NRO
  - Under Secretary of the AF – Joint with DNRO
- DARPA – “Virtual Space Office”
  - $100s M per year
  - Transformational Charter



UNITED STATES STRATEGIC COMMAND -- 1 OCT 2002

Our Mission

Establish and provide full-spectrum global strike, coordinated space and information operations capabilities to meet both deterrent and decisive national security objectives. Provide operational space support, integrated missile defense, global C4ISR and specialized planning expertise to the joint warfighter.

ACCESS TO SPACE ?

1986 Challenger

2003 Columbia

1998
Titan IV

Spacelift Needs

Annual Peacetime Launch Needs

1Klb Class

Payloads to LEO/Polar
•MicroSats

5-10 launches / year

15 Klb Class

Payloads to LEO/Polar/GTO
Payload Servicing
•Responsive Sats &
•Small Commercial Sats

15-30 launches / year

45Klb Class

Cargo/Crew to Station
Payloads to GEO
•Civil ISS
•National

10-15 launches / year

100+Klb Class

Beyond GEO/Large Sats
•SBL
•Multi-Mission space platforms
•Full LRS

5 launches / year

\+ \+ \+ \+

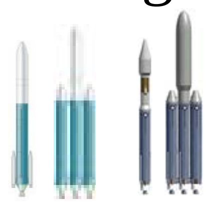
Annual War-time Launch Needs

1Klb Class	15 Klb Class	45Klb Class	100+Klb Class
10 launches	35 launches	2 launches	No addit'l launches

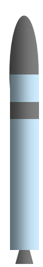
(Additional launches required for prewar augmentation and reconstitution given a near-peer competitor)

Spacelift Options

- Reference
  - Existing LV systems



- ELV
  - Liquid two stage
  - Solid three stage

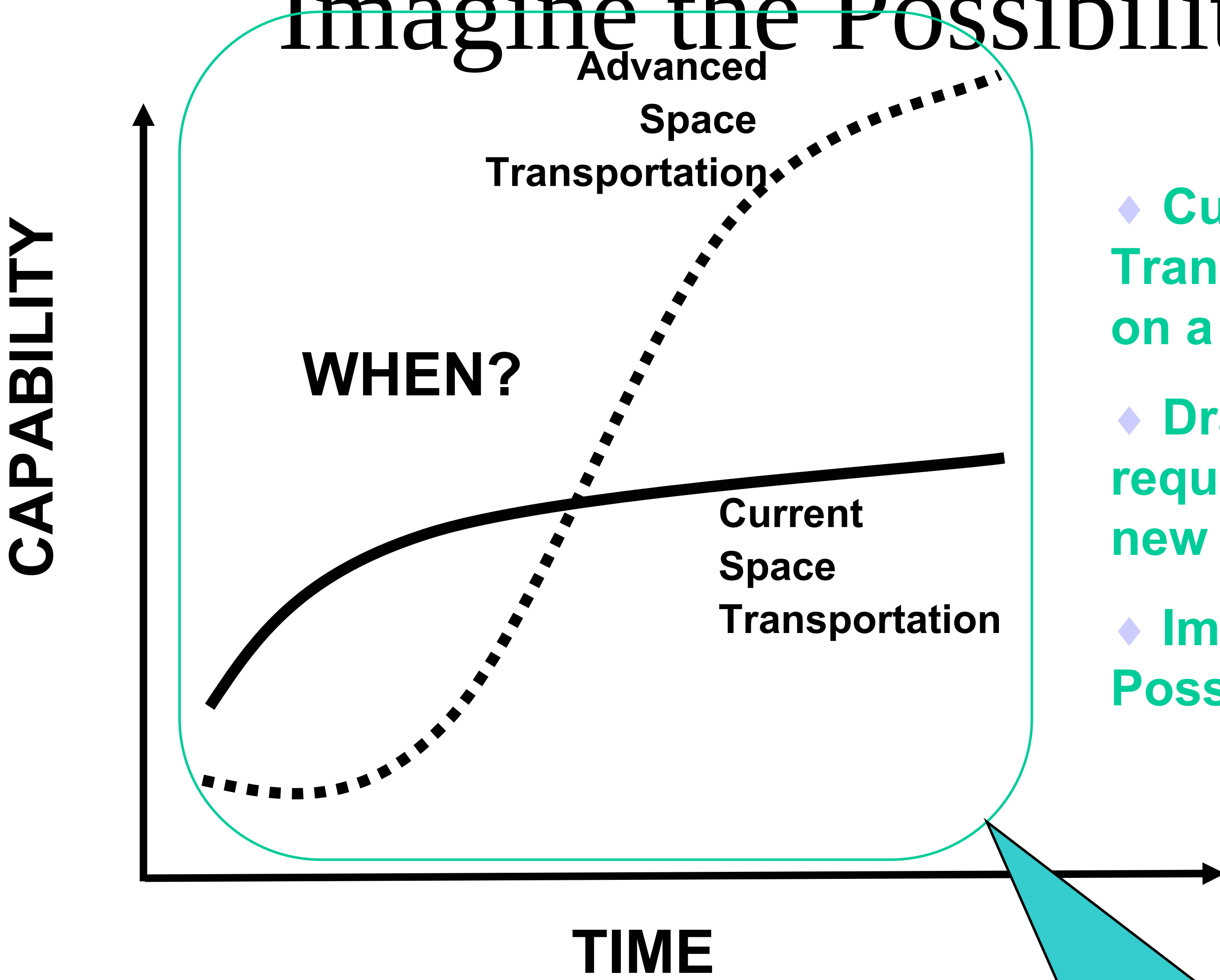


Payload Classes

- Microsat
- 5 klb
- 15 klb
- 25 klb
- 45 klb
- 100 klb

- RLV - TSTO
  - Optimized LH-LH
  - Optimized RP-RP
  - Optimized RP-LH
  - Bimese LH-LH
  - Bimese RP-RP
  - Hypersonic-Rocket

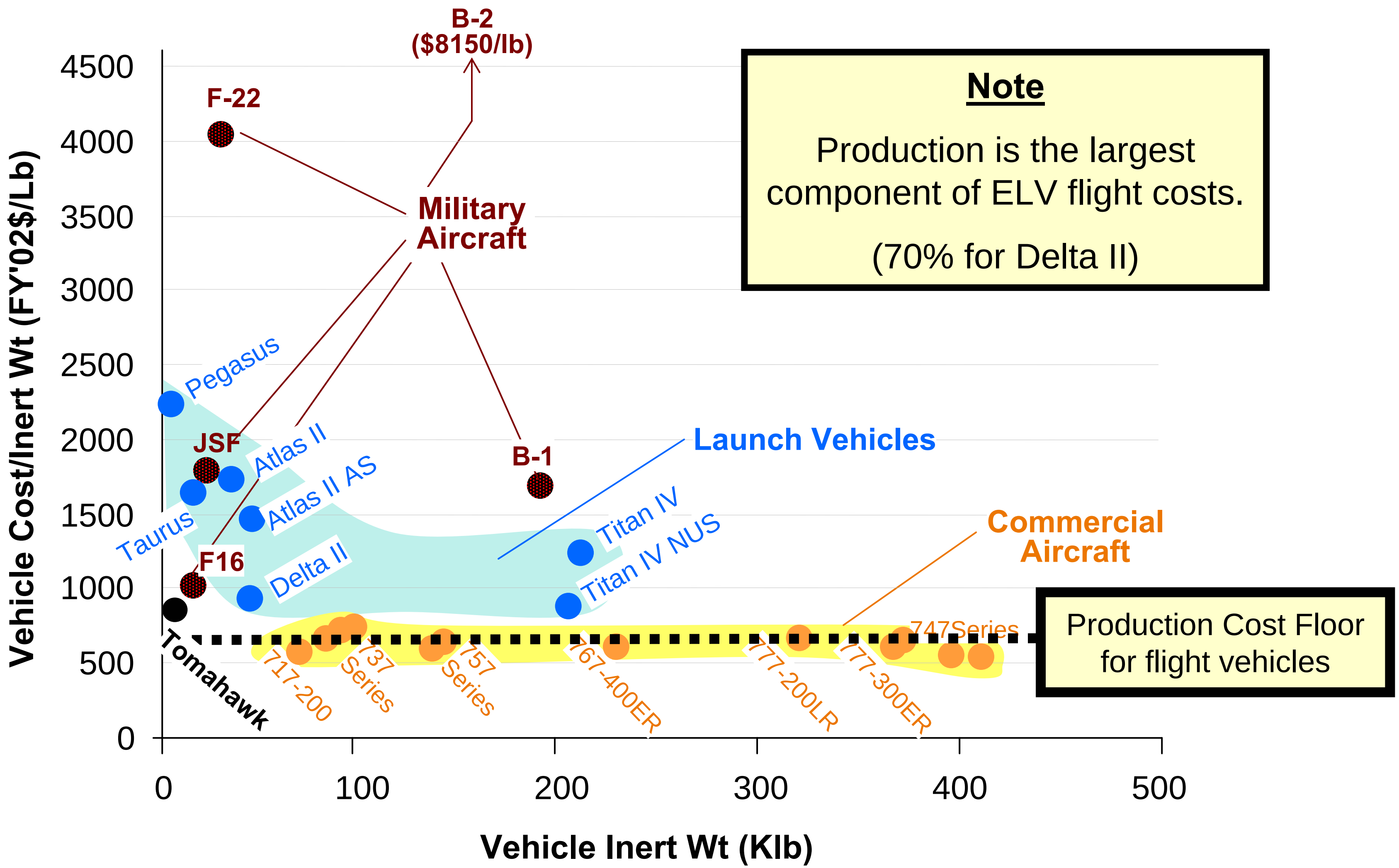
Imagine the Possibilities



- Current Space Transportation is paced on a shallow slope
- Dramatic Change requires investment in new technologies
- Imagine the Possibilities …

A National Initiative

Why RLVs?
A Glance at Production Costs

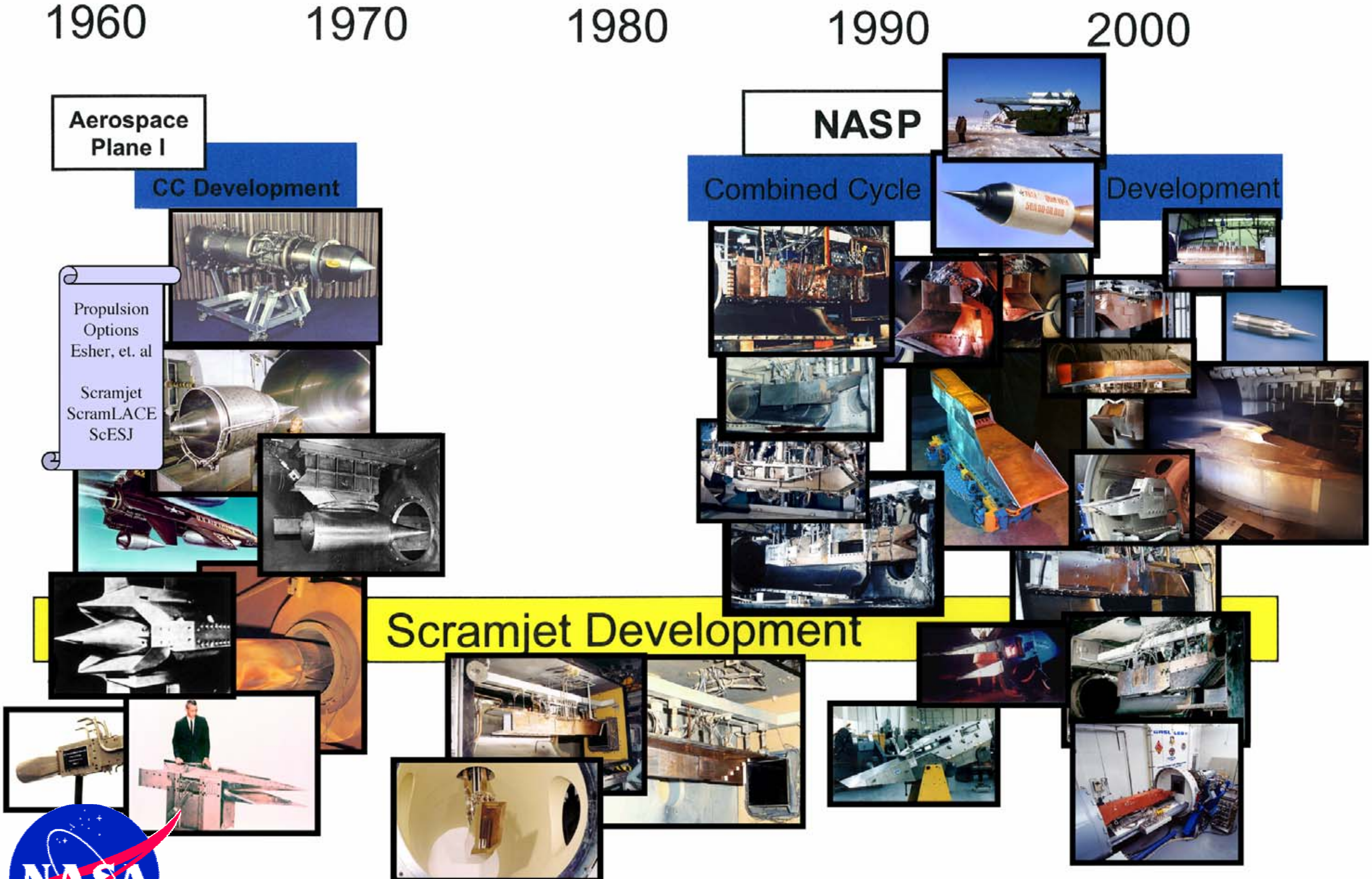


Note

Production is the largest component of ELV flight costs.

(70% for Delta II)

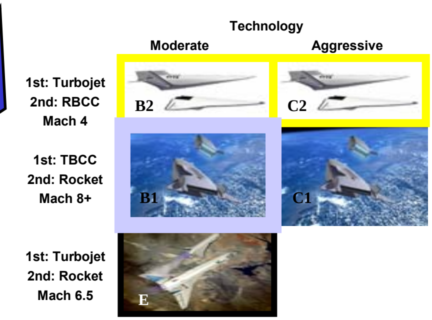
SPACE ACCESS AIRBREATHING ENGINE DEVELOPMENT(U)



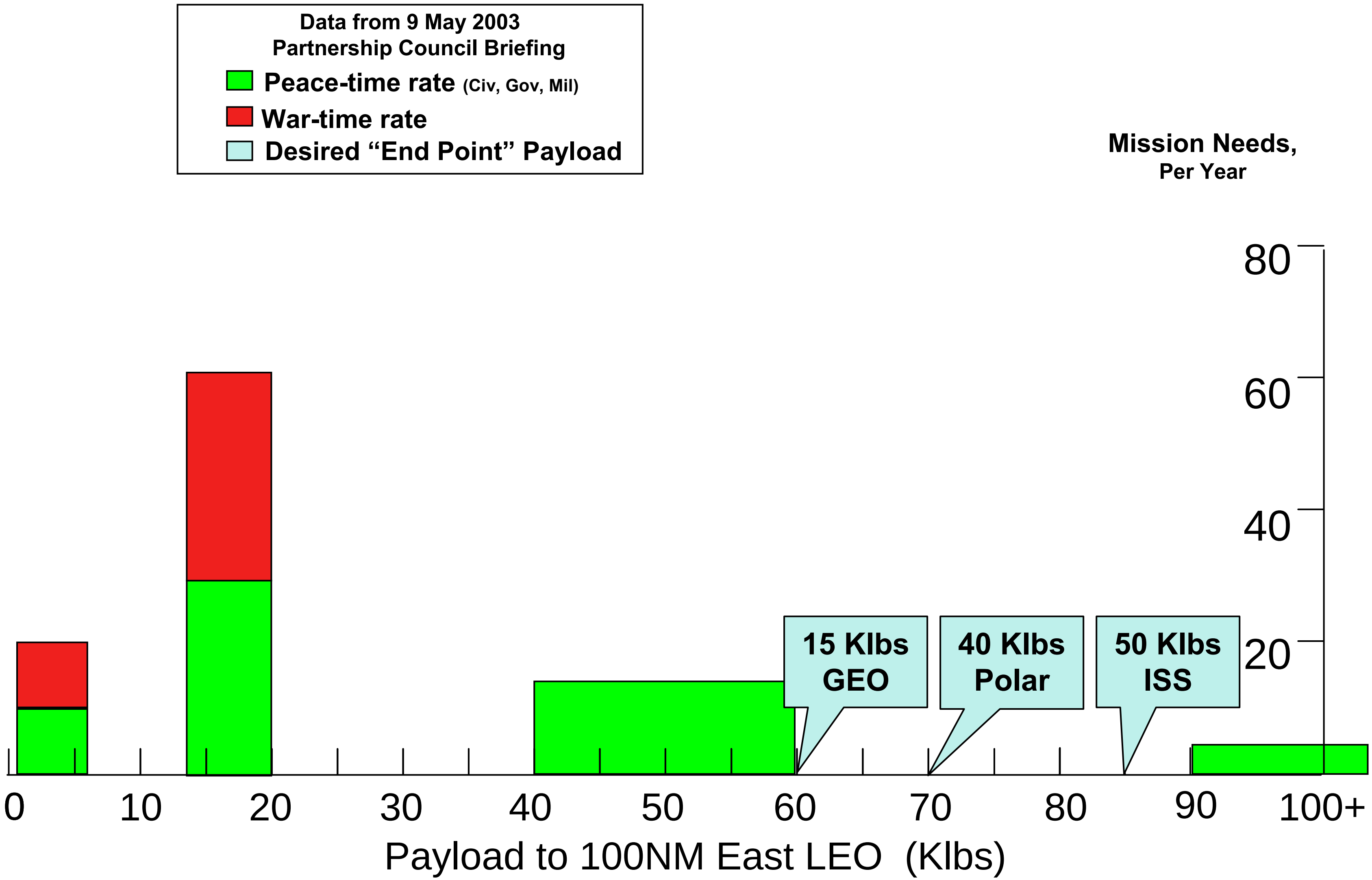
Configuration Summary HTHL

Technology Level

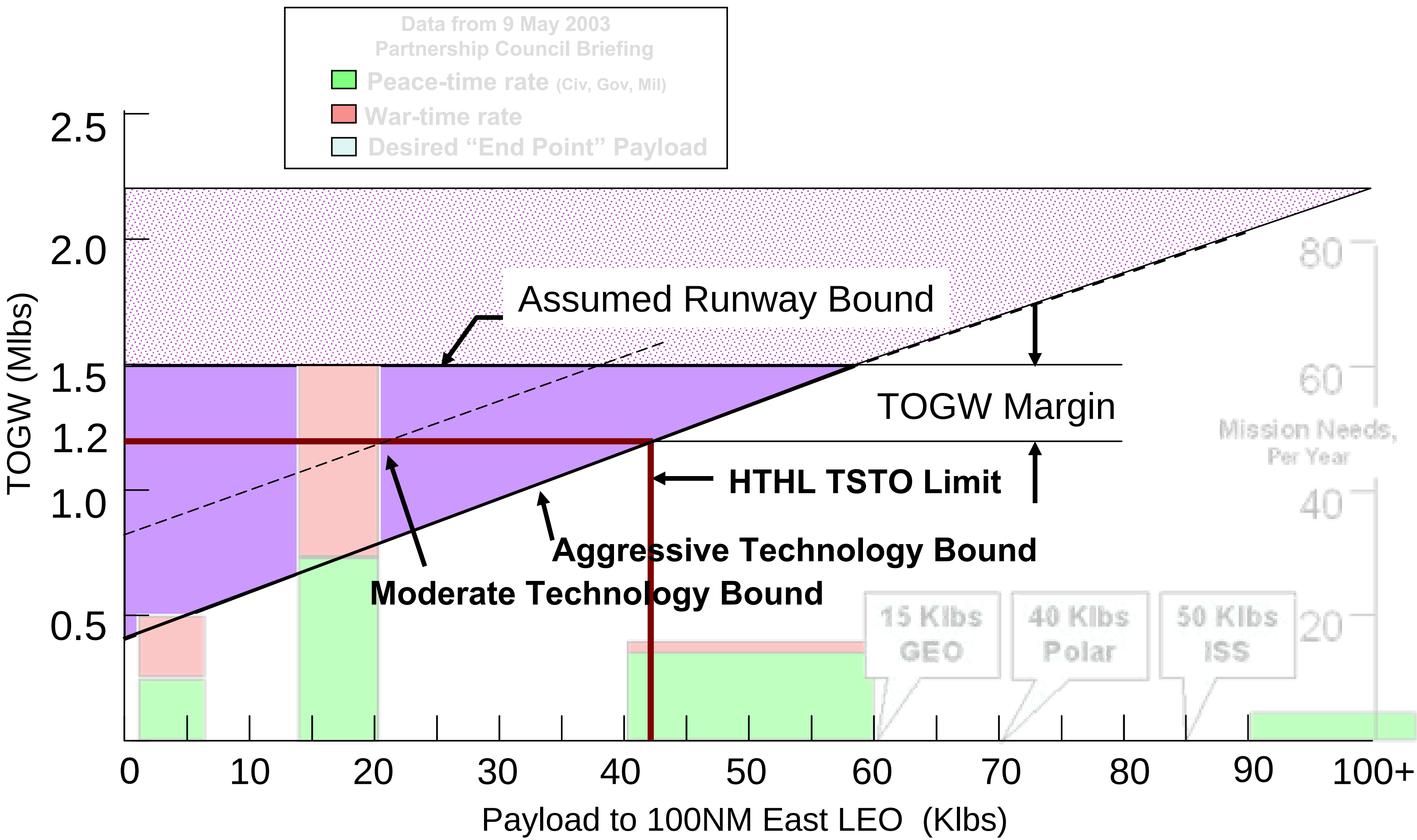
	Moderate	Aggressive
1st: Turbojet 2nd: RBCC Mach 4		
1st: TBCC 2nd: Rocket Mach 8+		
1st: Turbojet 2nd: Rocket Mach 6.5		



PAYLOAD NEEDS

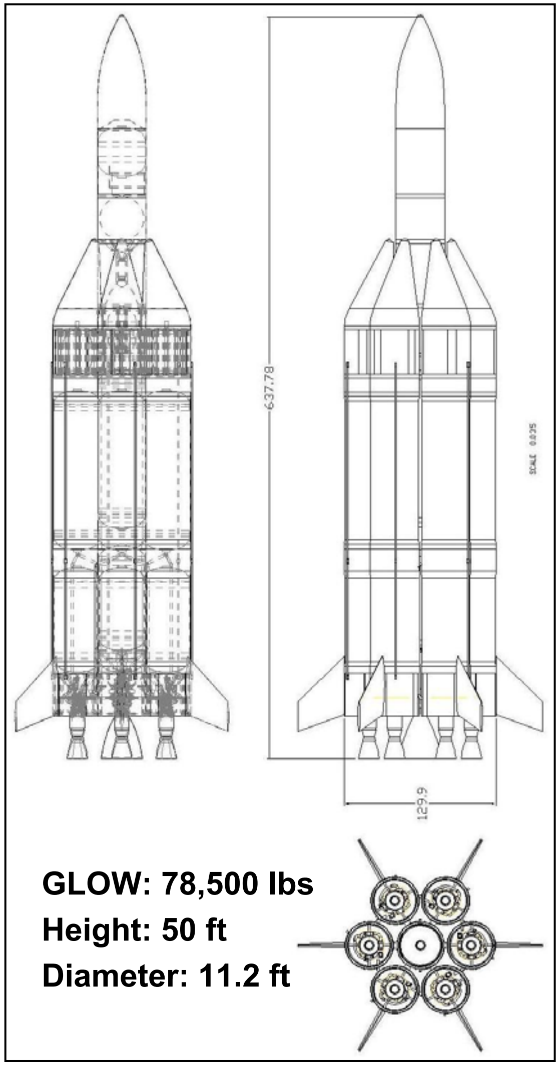


TSTO HTHL PAYLOAD CAPABILITY
Airbreathing Design Space

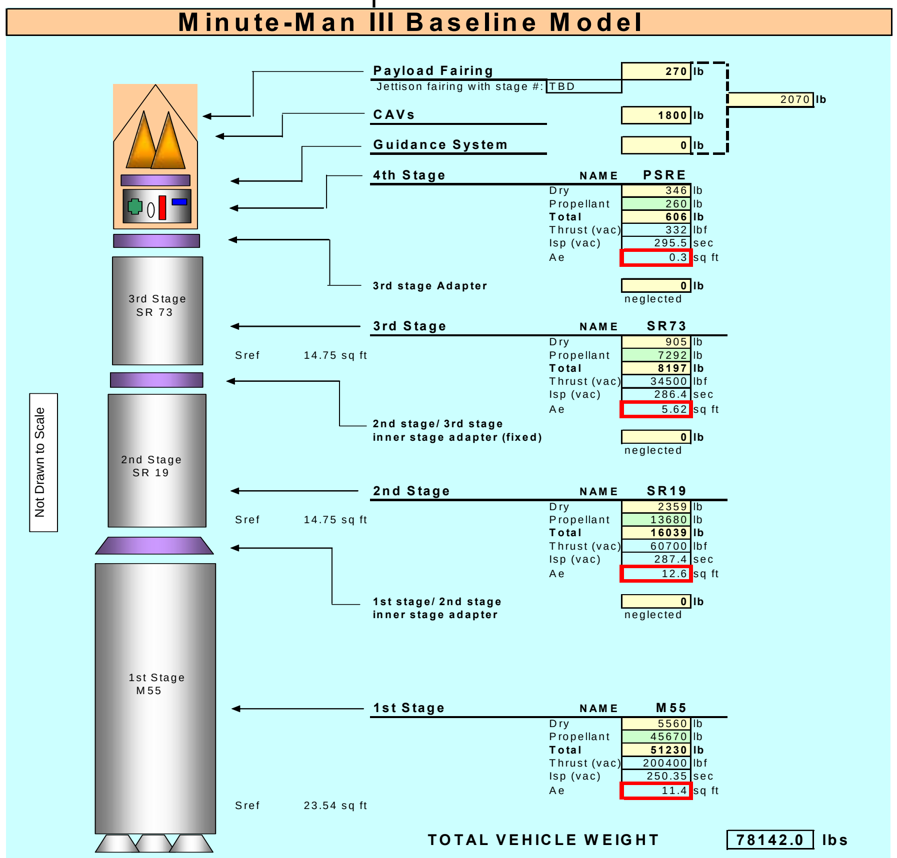


Sprite Small Launch Vehicle Example

- 3-Stage Vehicle
  - LOX/Kerosene Ablative Engines
  - Hi Performance Pressure Fed Pressurization System
  - Composite Tanks
  - Modular Vehicle, Common Stage
    - 6 for stage 1
    - 1 for stage 2 (vac nozzle)
  - 2.5klb thrust 3rd stage
- 600 lb payload to easterly LEO
- ~$5M estimated launch cost



Minuteman III Launch Vehicle

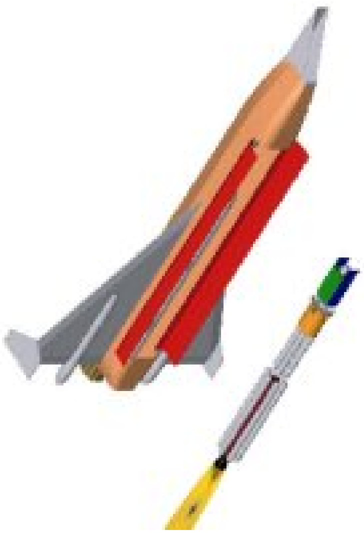


Falcon Summary (SpaceX)

- Payload capability: Approx 1100 lbs to LEO (28.5 deg)
- Launch from both Eastern and Western Ranges
- Multiple manifest, secondary, and piggyback capabilities
- Benign payload environment
- $6M per vehicle through 2004
- First launch possible by late 2003

- Diameter 5.5’ tapering to 5’
- Length 68’
- 1^{st} Stage Parachute/Water Recovery
- 1^{st} Stage Lox/RP1
- 2^{nd} Stage Lox/RP1

DARPA RASCAL LV

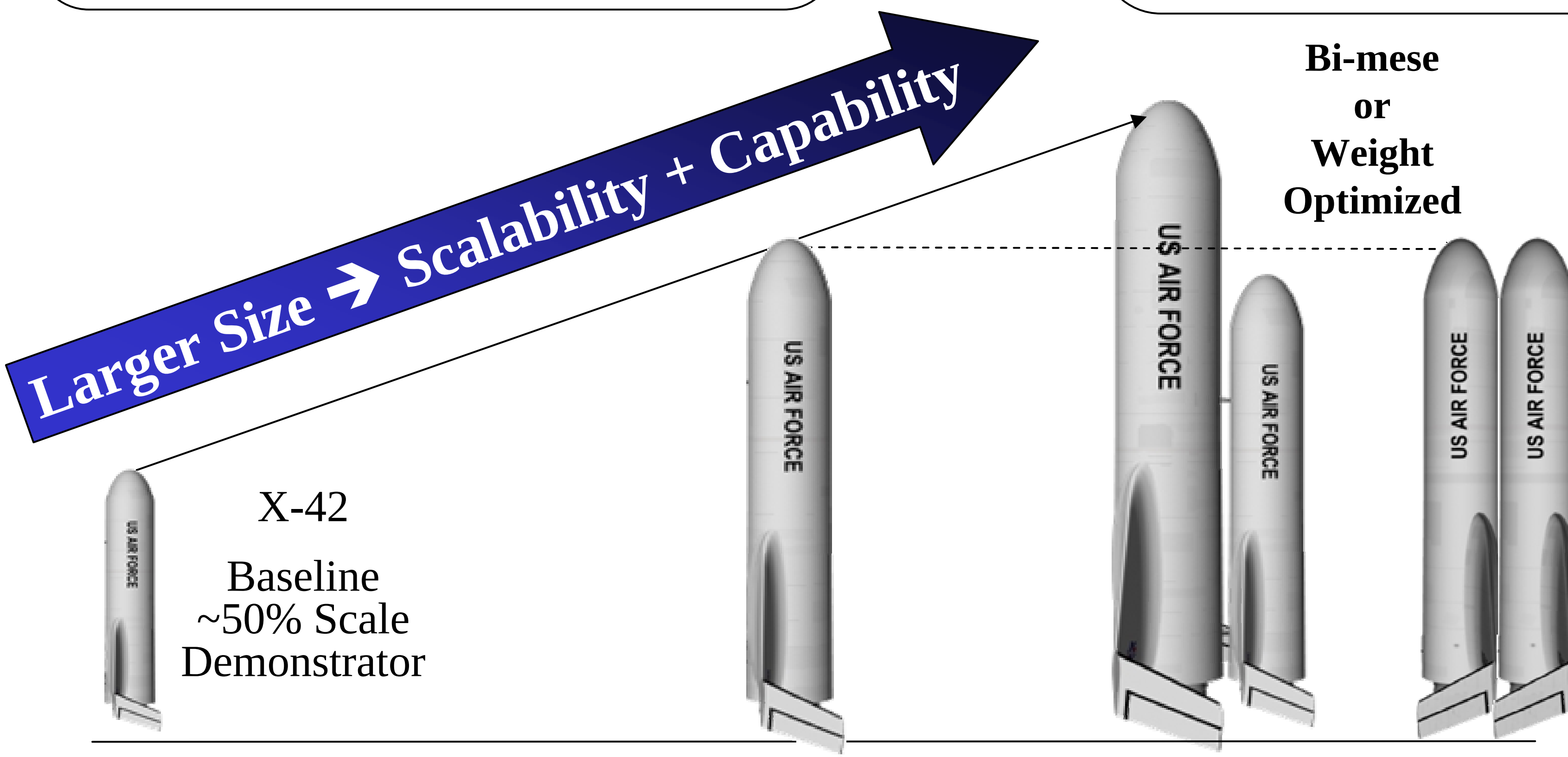


The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will design and develop a low cost orbital insertion capability for dedicated micro-size satellite payloads. The concept is to develop a responsive, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements. Specifically, the RASCAL system will be comprised of a reusable airplane-like first stage vehicle called the reusable launch vehicle and a second stage expendable rocket vehicle. The RASCAL demonstration objectives are to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low earth orbit at any time, any inclination with launch efficiency of $20,000 per kilogram or less.

X-42 PROPOSED PROGRAM

Pop-Up Demonstrator

TSTO System



NOTIONAL U.S. APPROACH

<u>Air Force</u>
- Launch System Design and Integration
- Launch Facility
- Landing System
- Flyback Engines
- Wiring
- TPS
- GN&C
- Expendable upperstages

Light RLV Ops Demo (10 Klb)

<u>NASA</u>
•Next Gen H2 Rocket
•Metallic cryo-tank
•Power
•Actuation
•Space-based Range
•IVHM/Avionics

- Operational Baseline
- Validated Systems Analysis
- Validated, Credible, Cost Estimates
- Validated Technologies Common to Larger Systems
- Validated vehicle upgradeable as medium 2nd stage
- Low cost light payload capability

Medium VTHL RLV (15-25klb)

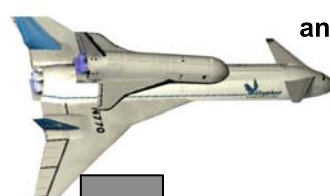
Heavy (40-60klb)

Very Heavy (80 klb)

Super Heavy Lift (200 klb)

Common Booster w/ ELV Core

Medium HTHL RLV (15-25klb)



and/or

Very Heavy Lift HTHL (200 klb)

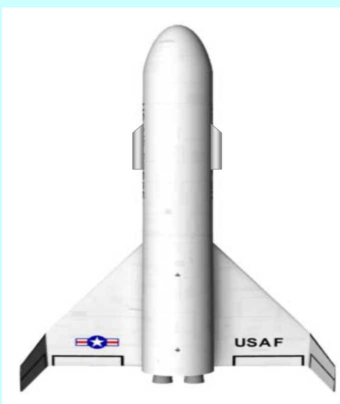
Medium HTHL Hypersonic (15-25klb)

Light RLV

Flight Cost* ~ $7 M

Turnaround ~ 24-72 hrs

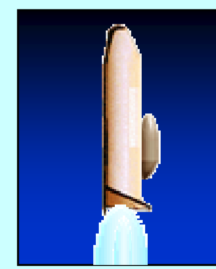
Reliable ~ 0.995+



Jet Engines allow incremental expansion of flight envelop with large number of flights

Hypersonic Technology Testbed

SmallSat Reusable Launcher

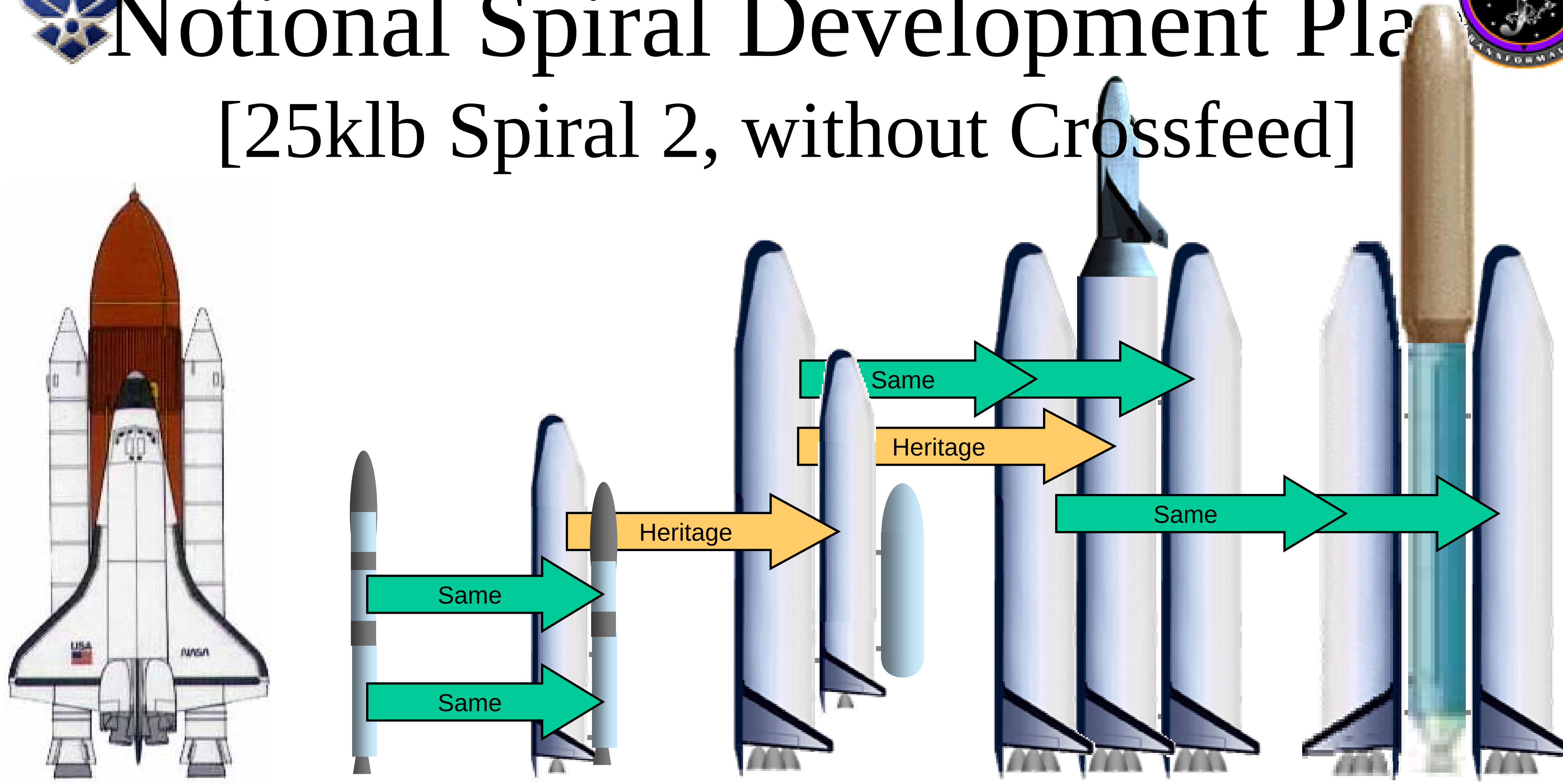


Experimental CAV Thrower

Cost includes: fixed & variable costs at a flight rate of 30/year, with no upperstage

Notional Spiral Development Pla

[25klb Spiral 2, without Crossfeed]

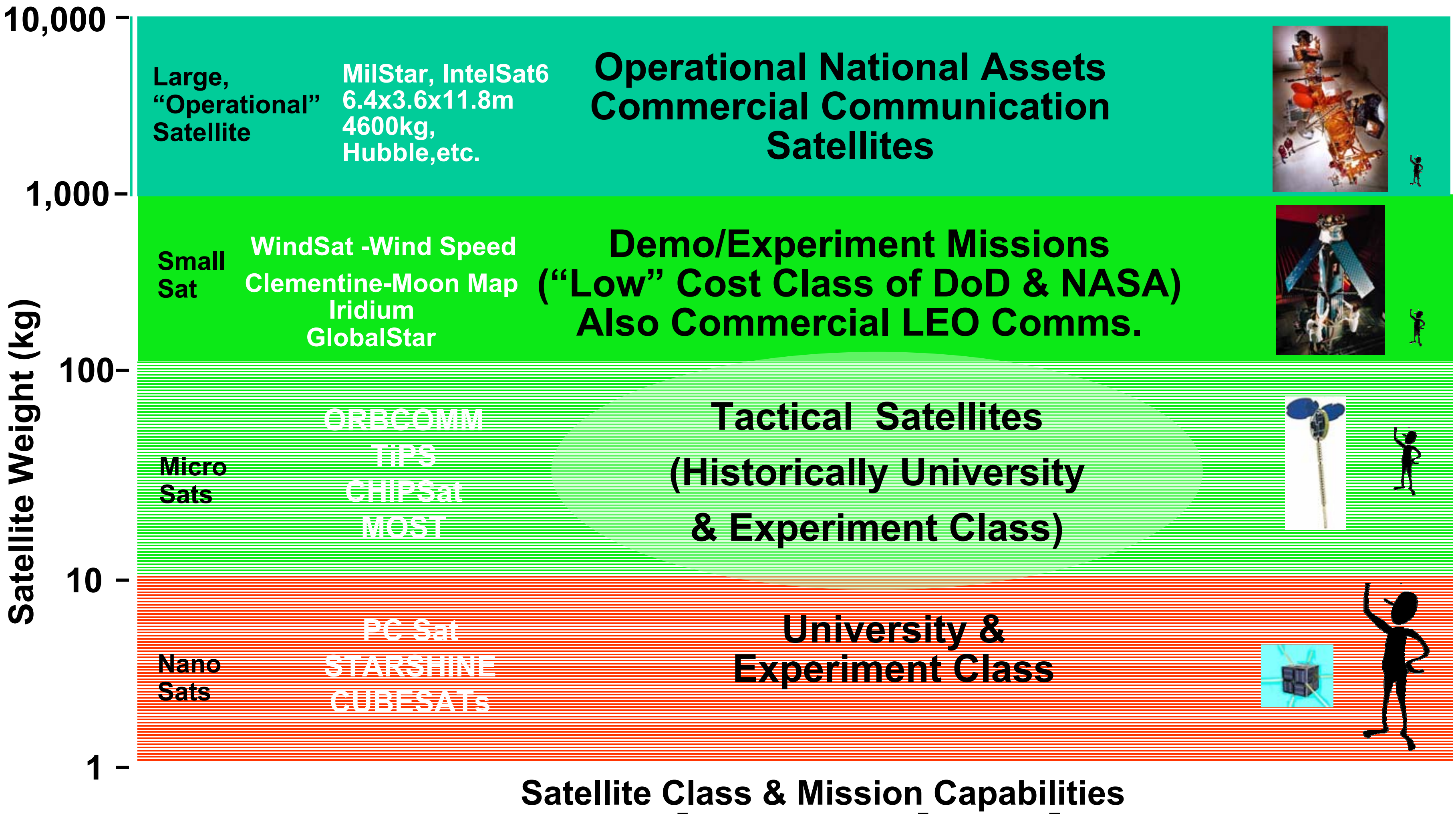


	FALCON	Spiral 1	Spiral 2	Spiral 3	Spiral 4
Stage 1 Engine	New RP	2 SSME	New LH Engine (4)	Same as Spiral 2	Same as Spiral 2
Stage 2 Engine	New RP	FALCON Stage 2	Spiral 1 Stage 1	Same as Stage 1	EELV Core
Stage 3 Engine	New RP	FALCON Stage 3	--	--	EELV US
Payload to LEO	1,500 lb	12,800 lb	25,000 lb	87,700 lb	~ 160,000 lb
Staging Delta-V		12,700 fps	12,800 fps	10,600 fps	14,400 fps
RLV Height	101 ft	112 ft	166 ft	166 ft	166 ft
RLV Dry Weight		90.0 klb	367.9 klb	763.8 klb	493.3 klb
GLOW	132.9 klb	580.7 klb	1,943.0 klb	4,389.5 klb	3,623.3 klb

RESPONSIVE SPACE

- Microsatellites
- Responsive Space

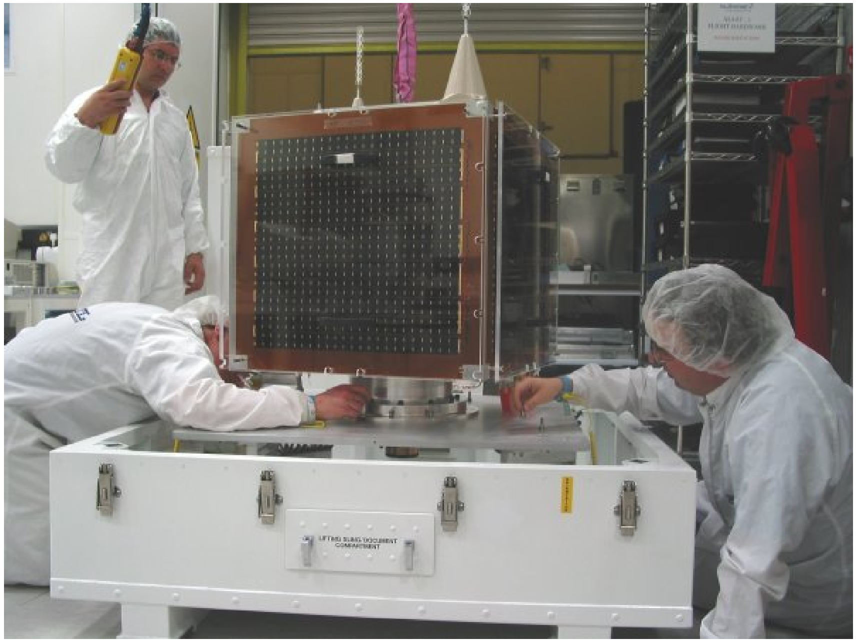
Satellite Size vs. Capability



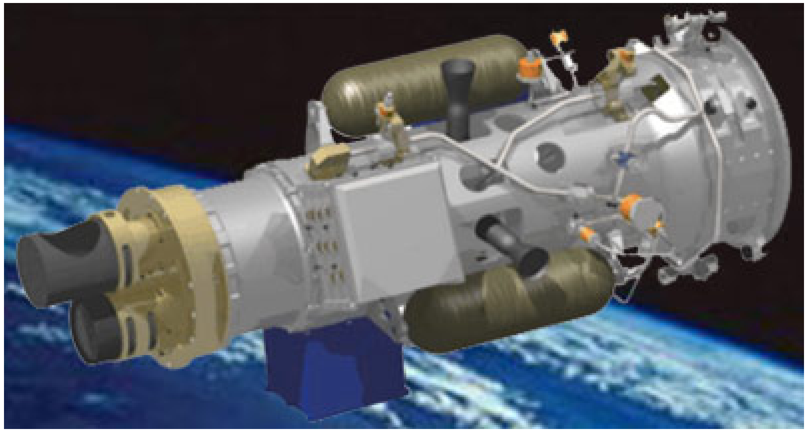
MicroSats in the <100 kg Class can Now Perform Valuable Niche Missions

GLOBAL MICROSATS
2002 HISTORY

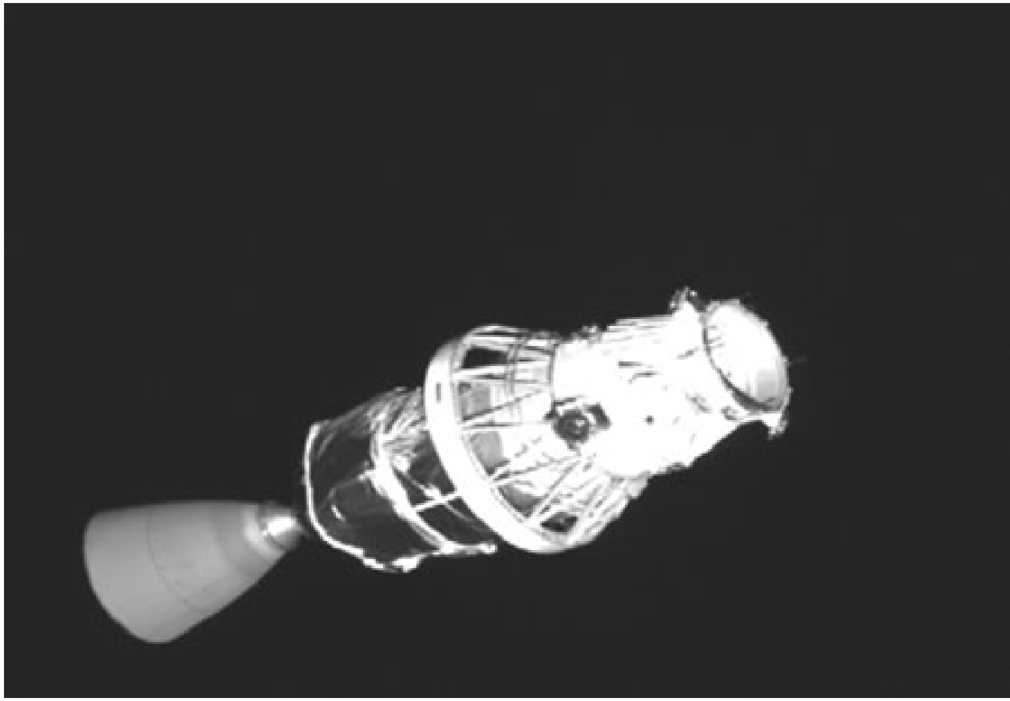
Microsat Name	Owner/Nation	Date Launched	Mass/Purpose
Dash	ISAS/Japan	4 Feb 2002	70kg/Technology
Kolibri-2000	Academy of Sci/Russia/Australia	Unk	20kg/Education
Unk	Tsinghua/China	Sep 2002 (failed)	Unk/Technology
Alsat 1	Algeria/Surrey(UK)	28 Nov 2002	92kg/Disaster Monitor
Mozhaets	Russia	28 Nov 2002	64kg/Science/Education
FedSat	Australia	14 Dec 2002	50kg/Science
WEOS	Chiba Inst/Japan	14 Dec 2002	68kg/Science
μ-lab Sat	NASDA/Japan	14 Dec 2002	68kg/Technology
Latin-Sat A,B	Argentina	20 Dec 2002	11.35kg @/Technology
UniSAT-2	Univ of Rome/Italy	20 Dec 2002	11.8kg/Science
SaudiSat-1c	Saudi Arabia	20 Dec 2002	Unk/Unk



U.S. AFRL XSS-10 MICROSAT PROGRAM, FEB 2003



COST: APPROX $60M
TIME: 6 YEARS



OTHER EFFORTS: JUNE 2000

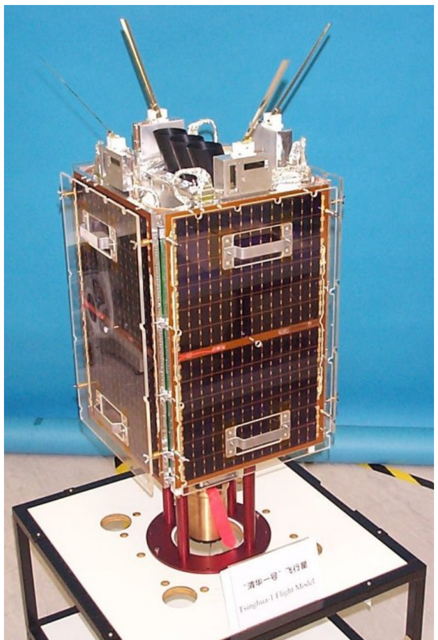


Figure 7 Tsinghua-1 Microsatellite

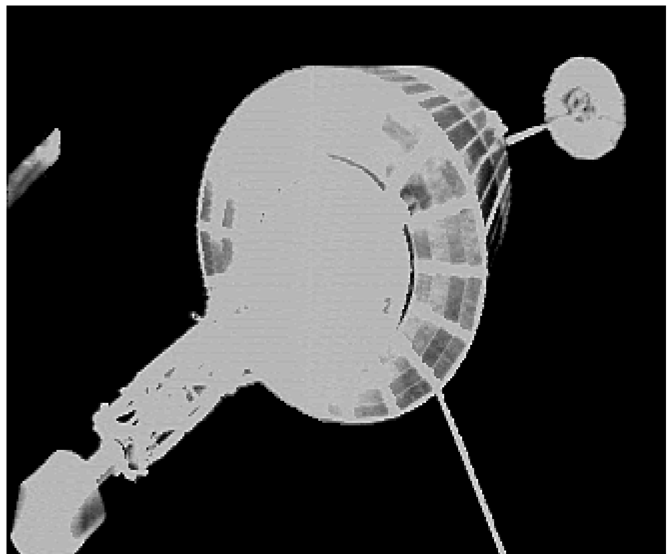


Figure 8 Russian COSPAS-SARSAT Satellite Image Taken by SNAP-1

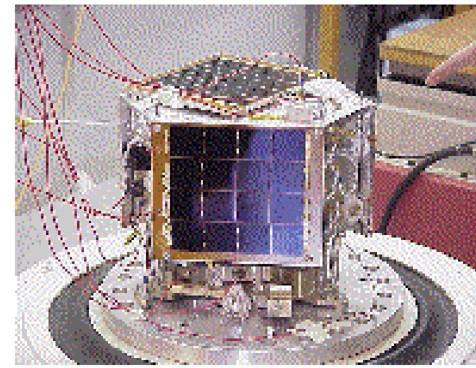
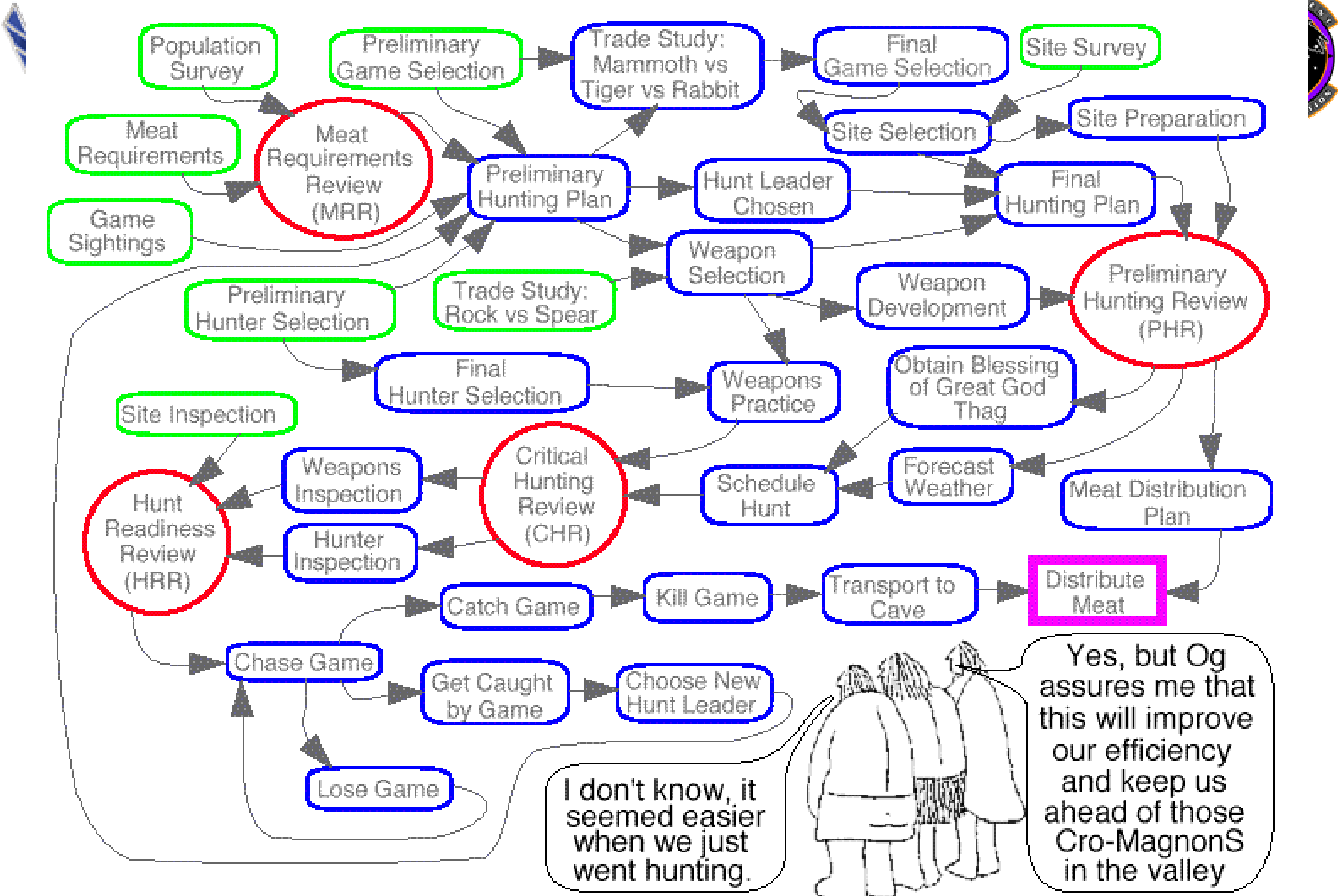


Figure 6 SNAP-1 Nanosatellite

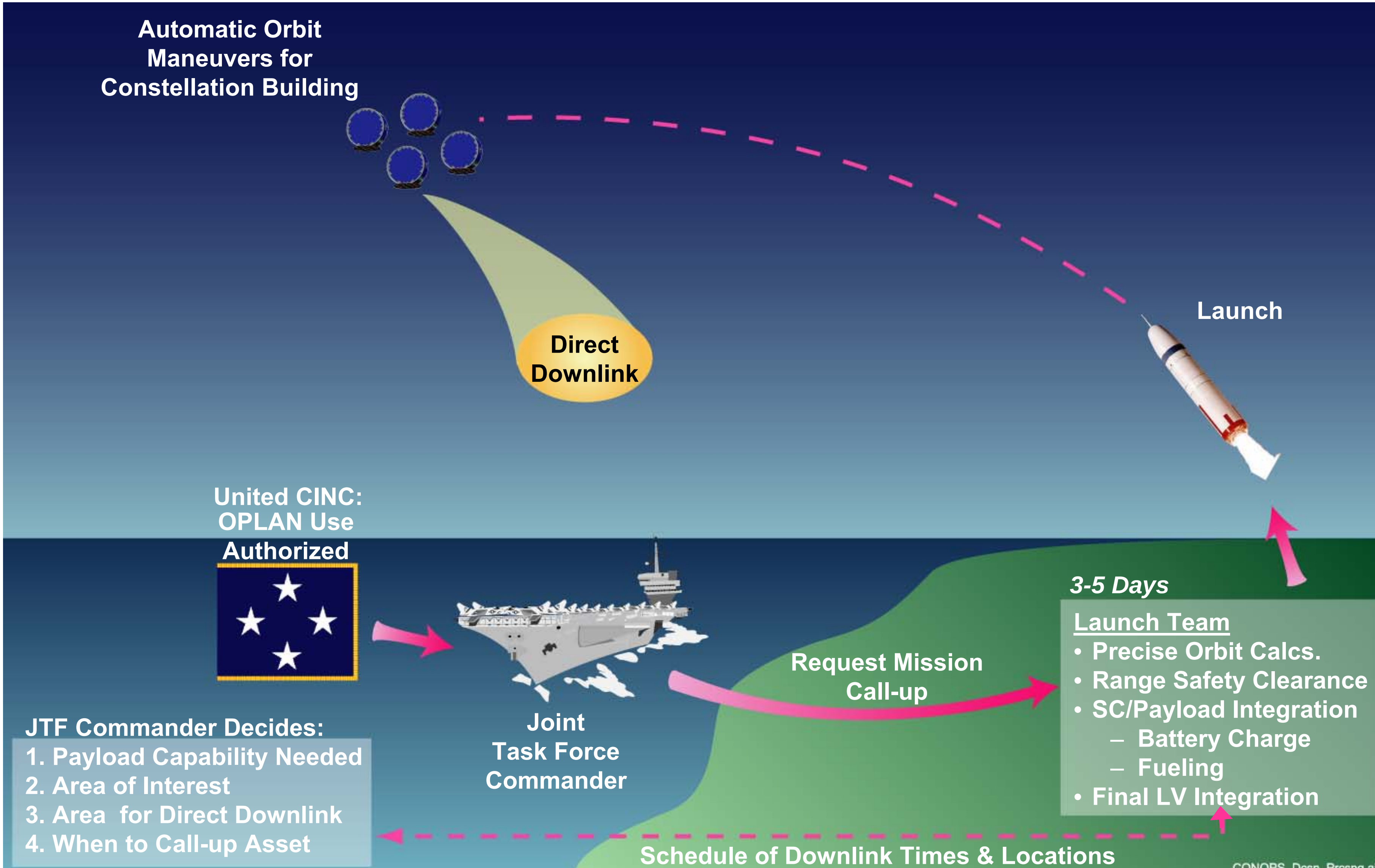
COST: APPROX $1M
TIME: 1 YEAR



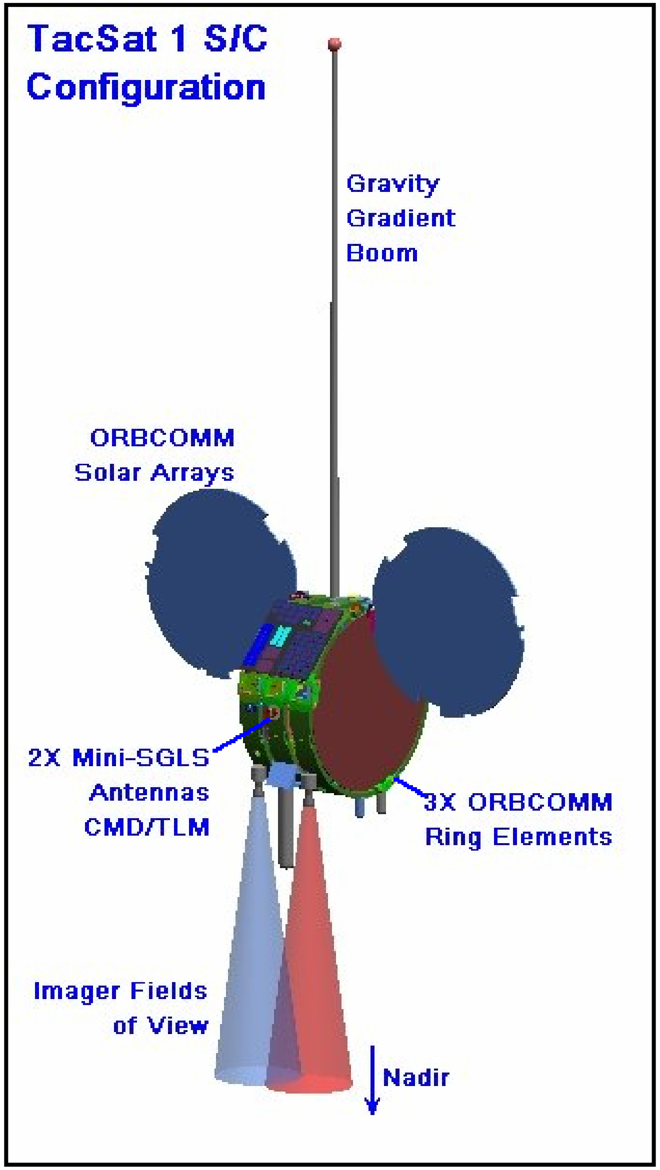
Why the Neanderthals became extinct.

CONOPS: Launch Decision and Processing

RESPONSIVE SPACE - TACSAT 1 2004



TacSat-1: Spacecraft & Mission Highlights

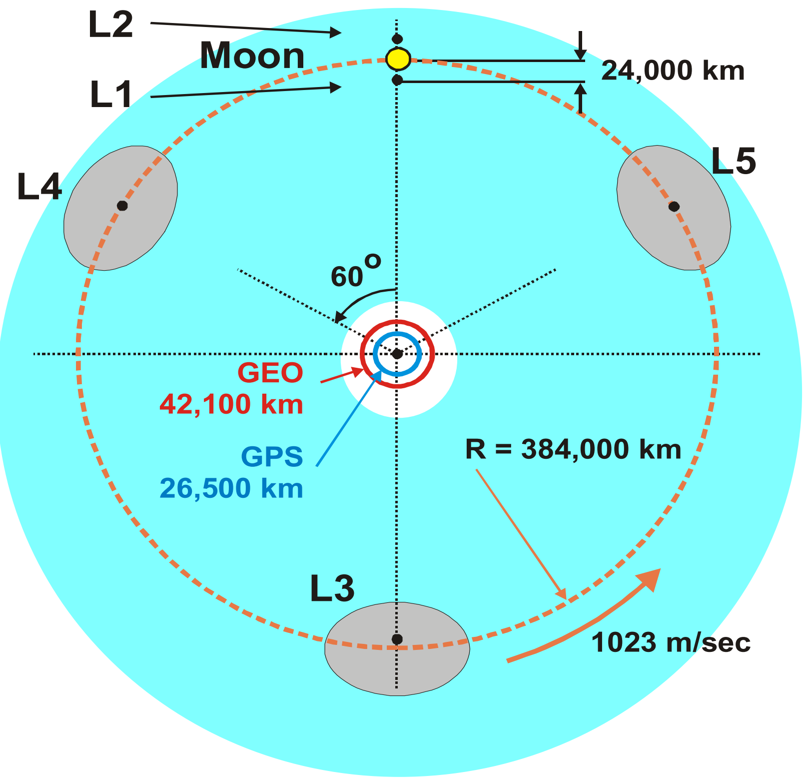


- Size:
  - 41 inches Diameter, 18 inches High
- Mass:
  - Bus: ~60 kg
  - Copperfield-2S: 20 kg
  - Imager: 10 kg
  - Total: ~90 kg
- Power:
  - Available: 186W
  - Bus: 55W OAP, 75W Peak
  - Payload: ~70W Peak
- Orbit:
  - Altitude: 400-450km
  - Inclination: ~63 Degrees
- Mission Life:
  - Approximately 1 Year

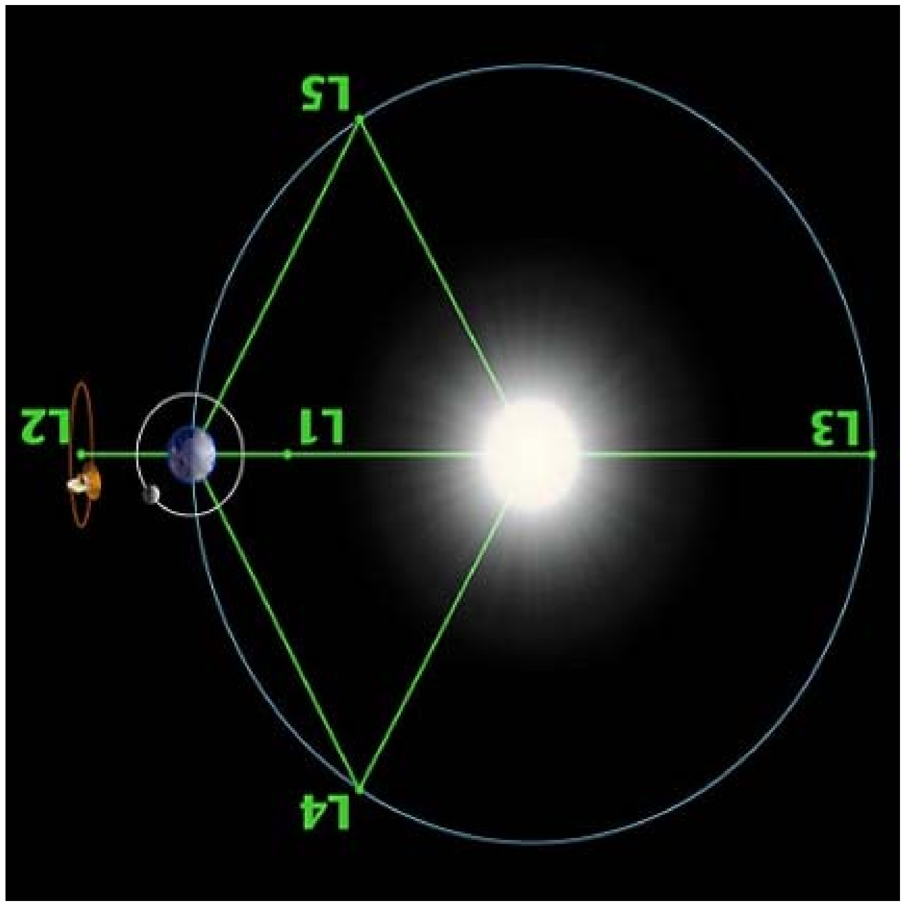
Cis-Lunar Space

Cis-Lunar Space (Near Earth Deep Space)

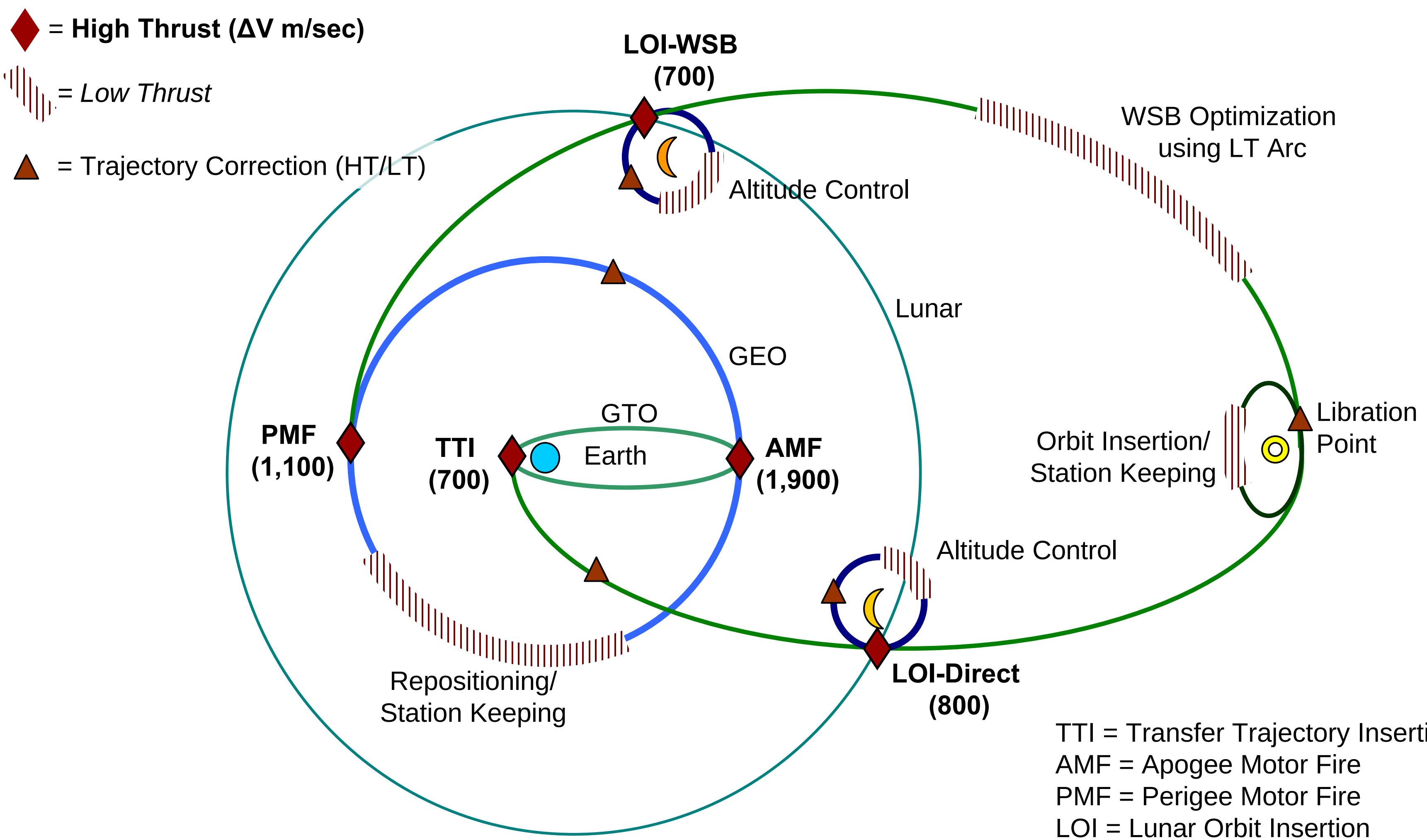
- Earth-Moon System
- Lagrangian (Libration) Points
  - L1, L2, L3 – Unstable
  - L4, L5 – Stable
- Minimal Propellant Requirements for "Station- Keeping"
- "Clean environment" for science experiments
- Region of Interest for MiDSTEP in Blue



TRANSLUNAR SPACE



Cis-Lunar Mission Concepts

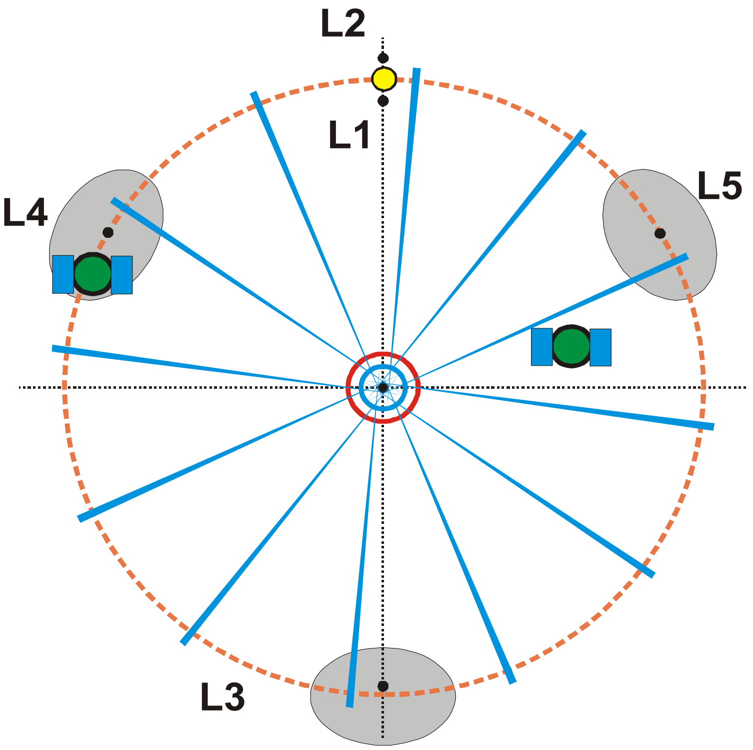


TTI = Transfer Trajectory Insertion
AMF = Apogee Motor Fire
PMF = Perigee Motor Fire
LOI = Lunar Orbit Insertion
WSB = Weak Stability Boundary

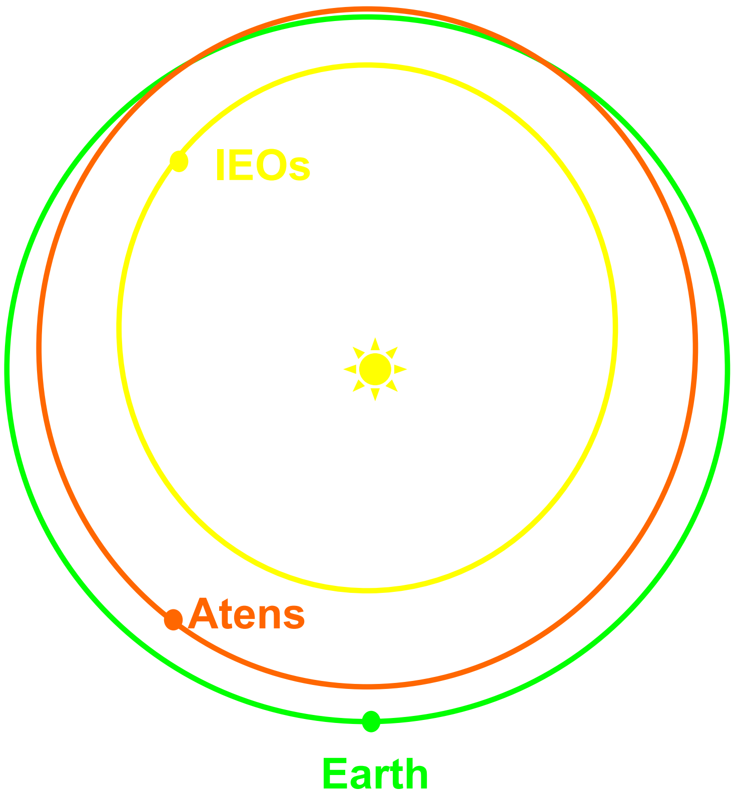
Navigation

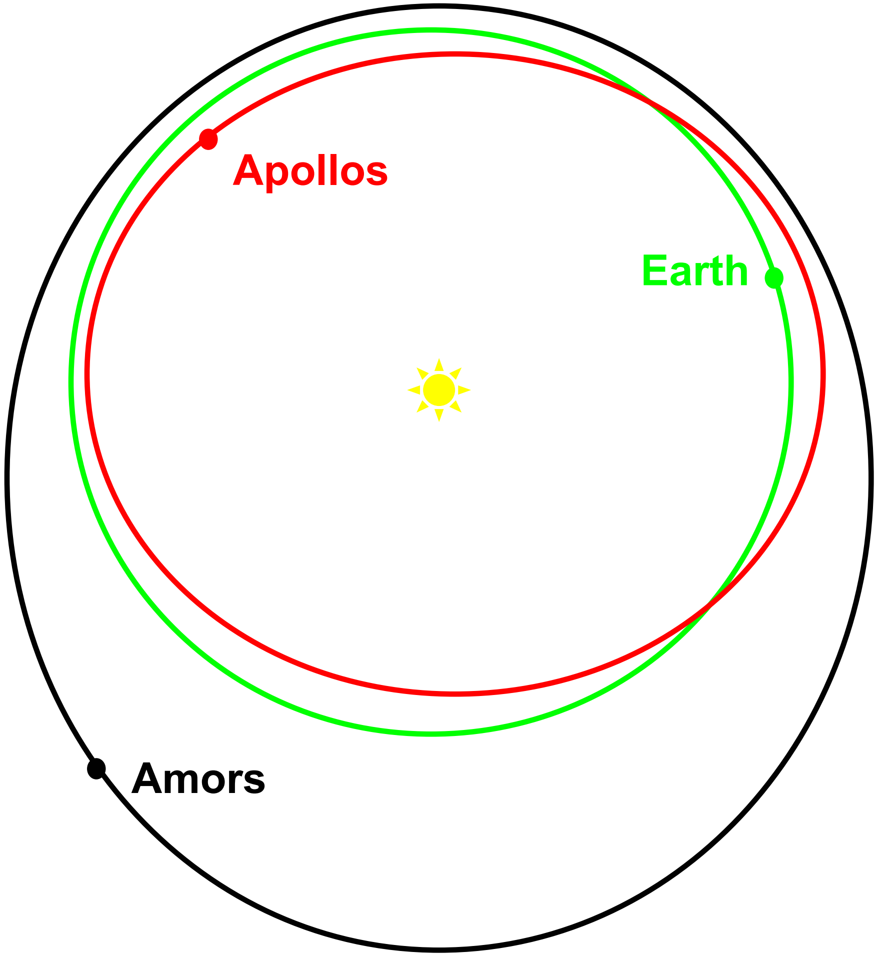
1. Navigation in Cis-Lunar Space

- Tasks
  - Station-Keeping and Repositioning
  - Maneuvering
  - On-Orbit Storage
    - “Wandering” in Cis-Lunar Space (e.g., Near L1/L2)
    - Transferring Into Moon-Circling Orbit
  - Autonomy
- Propulsion
  - Solar Sailing
  - Electric Propulsion
- Navigation Aid
  - ”Leaking” GPS Signals



Classes of Near-Earth Asteroid Orbits





HAZARD SUMMARY (2003 NASA REPORT)

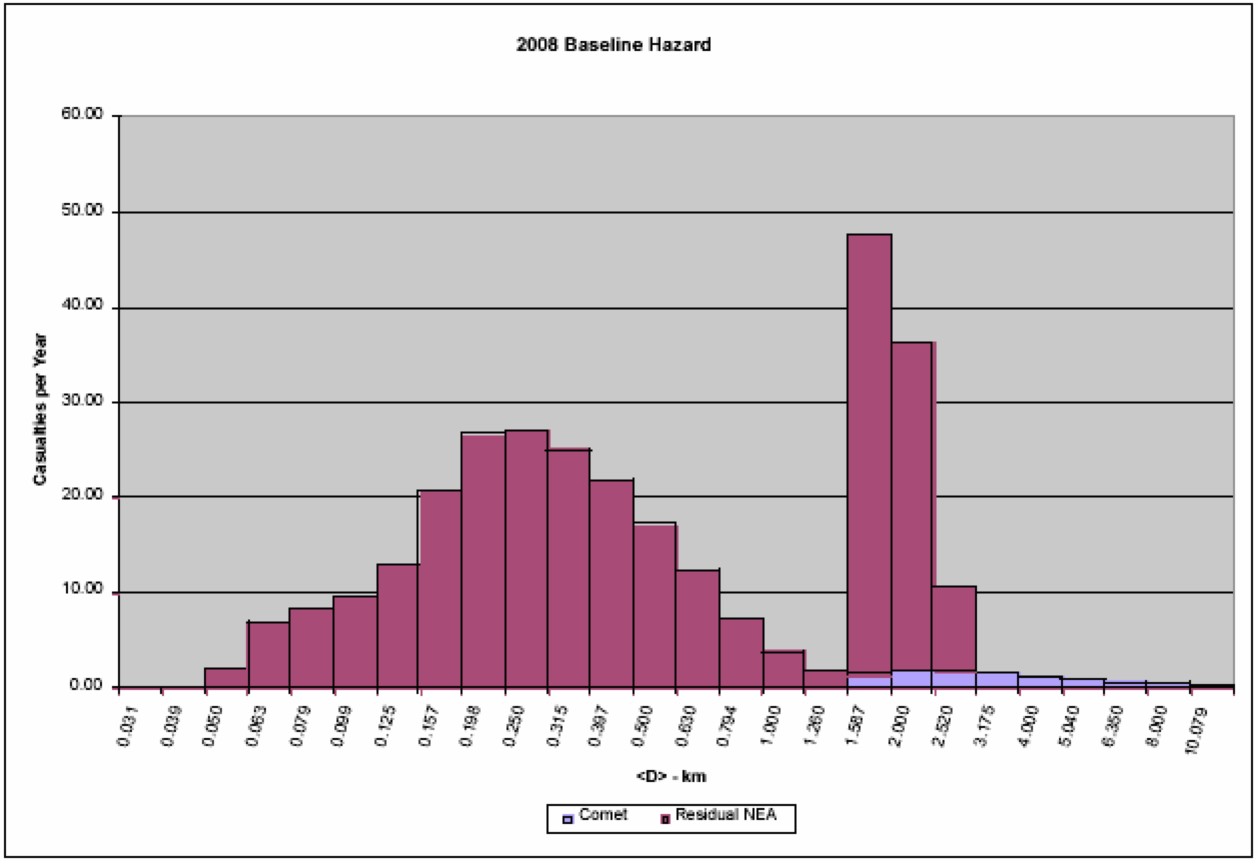
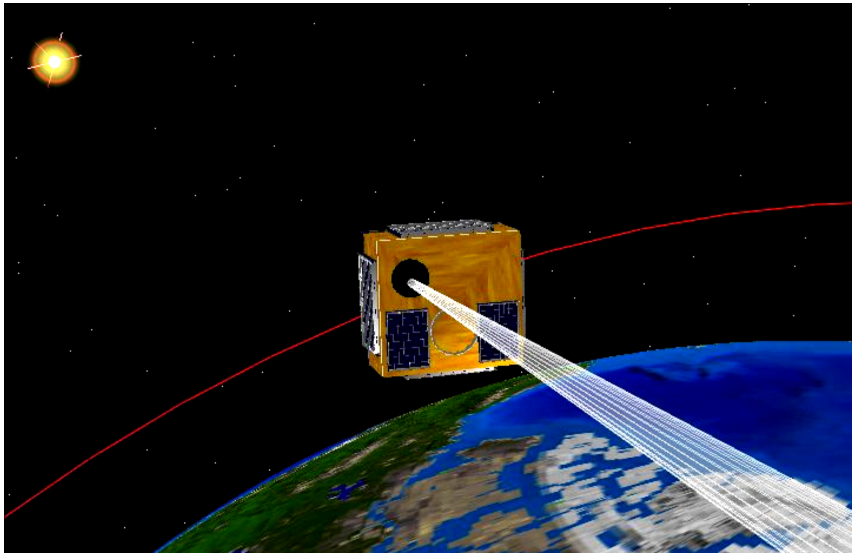


Figure 3-9: Residual impact hazard from all sources, including LP comets.

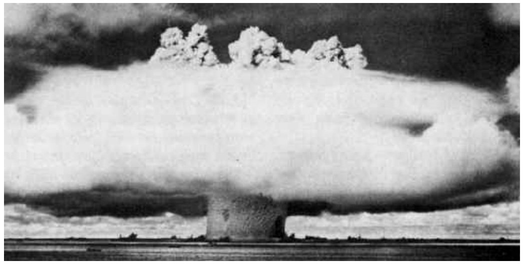
MOST: "Microvariability and Oscillations of STars"



- First CSA microsatellite.
- Space astronomy mission.
- Dynacon is Prime Contractor

- ***Status:***
  - In Phase D; pre-ship review by end of 2001
  - Launch scheduled for early 2003 (on Delta-2, with Radarsat 2).
- ***Innovative Elements:***
  - Highly-accurate (~ 10 arc-seconds) attitude control.
  - Science-grade imaging telescope.

MITIGATION



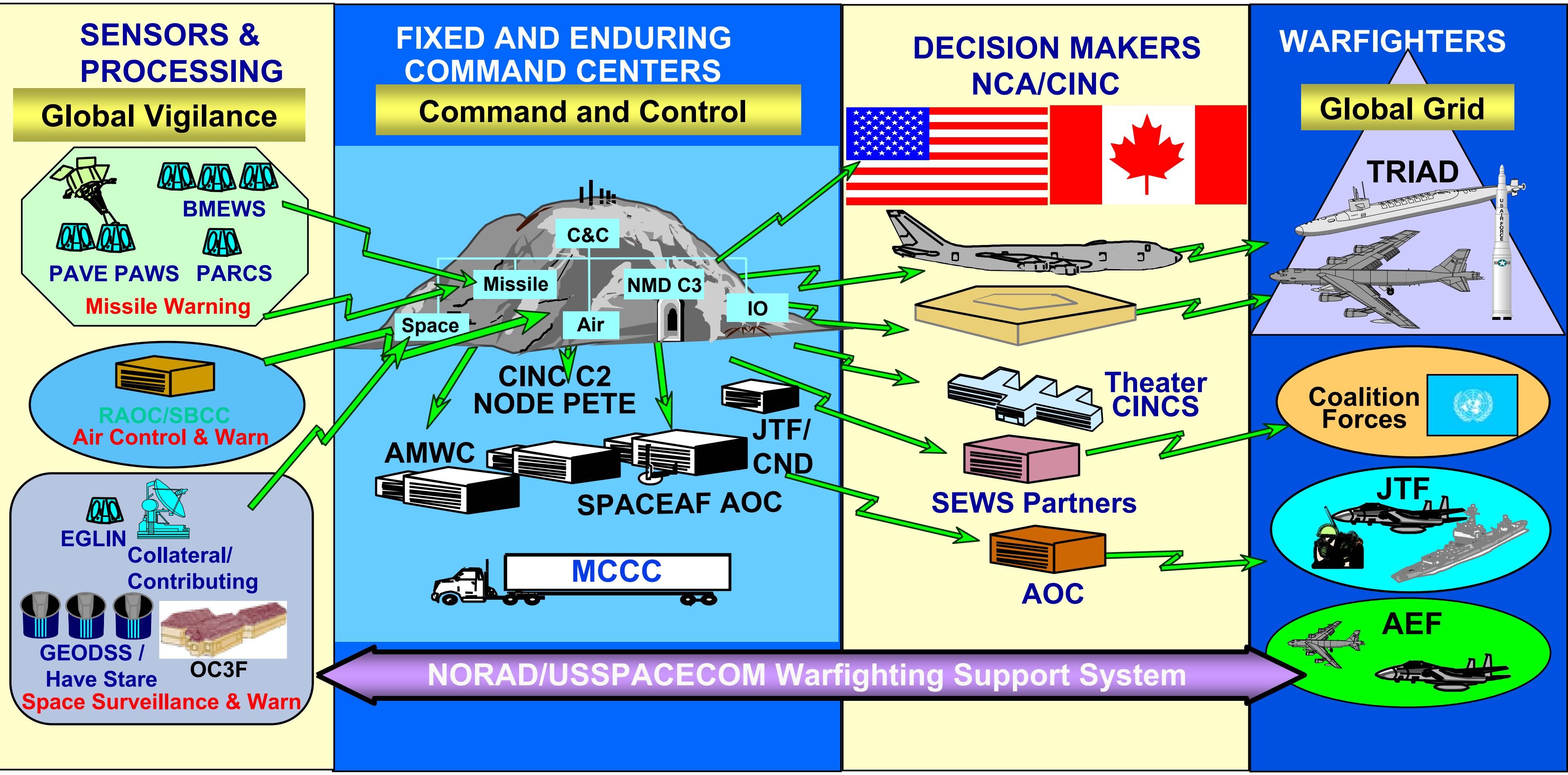
MITIGATION

- Near-Term -- “Kiss it goodbye”
- Best-Identify objects decades or centuries out
  - Explore Object
  - Divert using “conventional” means
    - Chemical or Electric Propulsion
    - “Impact” movement
    - “Yarkovsky” Effect -- use solar radiation pressure
- Surprise Object -- especially a “Comet”
  - Diversion “Hard”
  - Disruption “Dangerous” - “Rubble Pile” Problem
  - “Kiss it Goodbye”
- “GIGGLE FACTOR”!!!

MITIGATION - COMMAND AND CONTROL

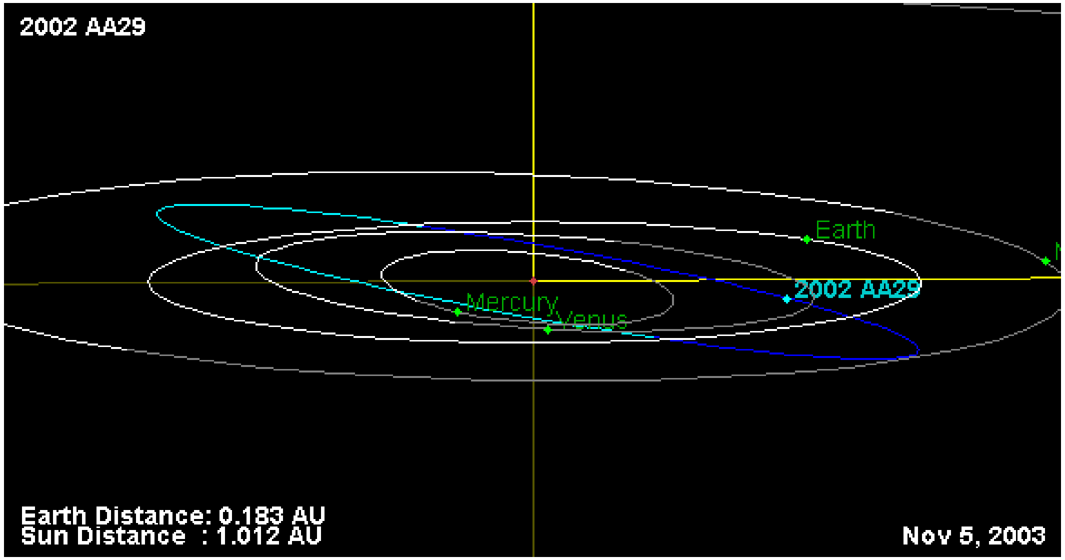
- The Real Issue on Planetary Defense is not “Weapons” -- its “COMMAND AND CONTROL” -- C-2
  - Who identifies the Threat?
  - Who believes that its real and why?
  - Who tells whom about the Threat?
  - Who decides what to do?
  - Who builds and executes the operation?
  - Who pays?
  - Who coordinates with all the effected parties?
  - Who tests the mitigation method?
  - Who gets blamed when it goes wrong?

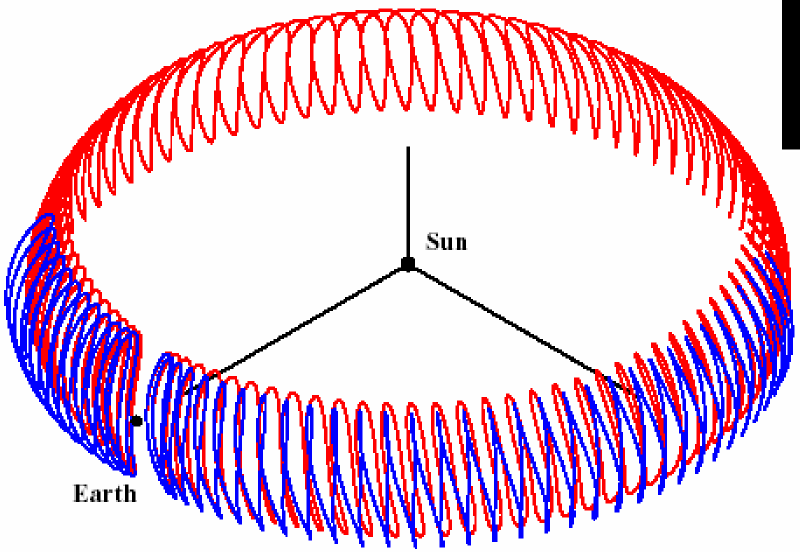
C2 Environment for Today's Missile Warning



Align With Global Warfighter/C2 Goals

ASTEROID 2002 AA_{29}

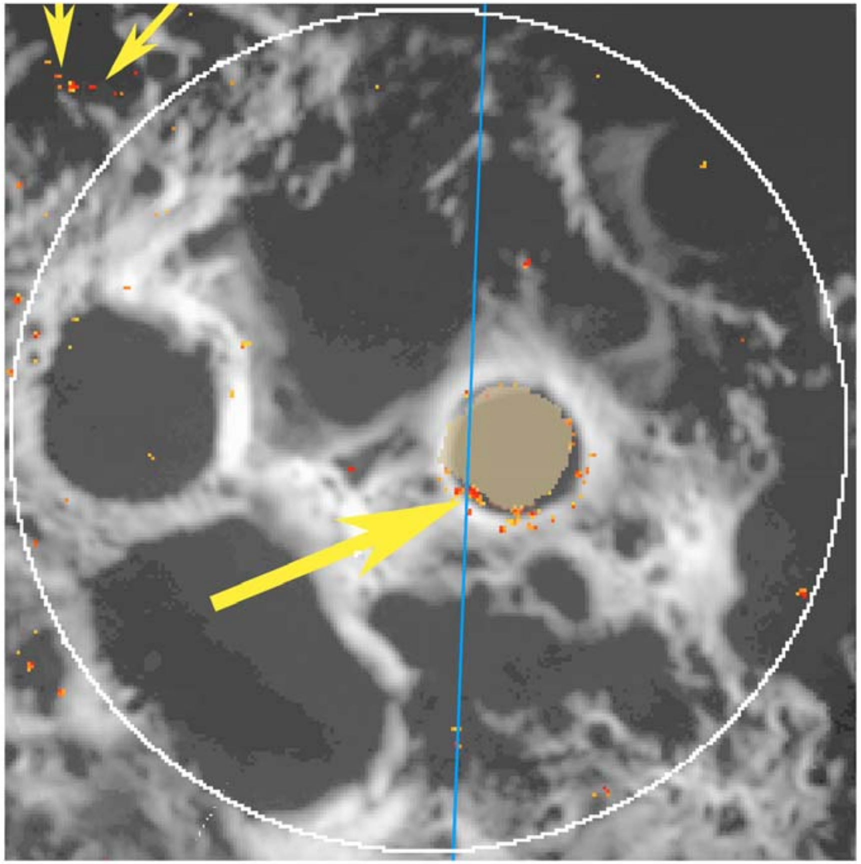




NEO Way Ahead

- USE MICROSATS TO IDENTIFY SUITABLE NEOS -- ESPECIALLY “HORSESHOE” ORBIT OBJECTS
- MOUNT SURVEY AND SAMPLE RETURN MISSIONS WITH MICROSATS
- CONDUCT “MANEUVER” EXPERIMENTS
- IF SUITABLE OBJECT CAN BE FOUND “MOVE” INTO EARTH ORBIT

LUNAR SOUTH POLE
"PEAKS OF ETERNAL LIGHT"



JAMES WEBB SPACE TELESCOPE

25 YEAR SPACE PROGRAM

- DEVELOP AFFORDABLE “RESPONSIVE” LAUNCHERS 2010-2015
- USE MICROSATELLITES TO SURVEY CISLUNAR SPACE, SUITABLE NEOS AND LUNAR POLES 2008-2018
- EVOLVE FULLY REUSABLE HEAVY LIFT AND PARTIALLY REUSABLE VERY HEAVY LIFT VEHICLES 2015-2020
- CONSTRUCT VERY LARGE SPACE TELESCOPE (PLANET FINDER) 30 METERS IN DIAMETER AT L-2 - 2020-2025
- DEVELOP LUNAR/NEO RESOURCE USAGE 2020-2025
- MOVE NEO INTO EARTH ORBIT 2025-2030